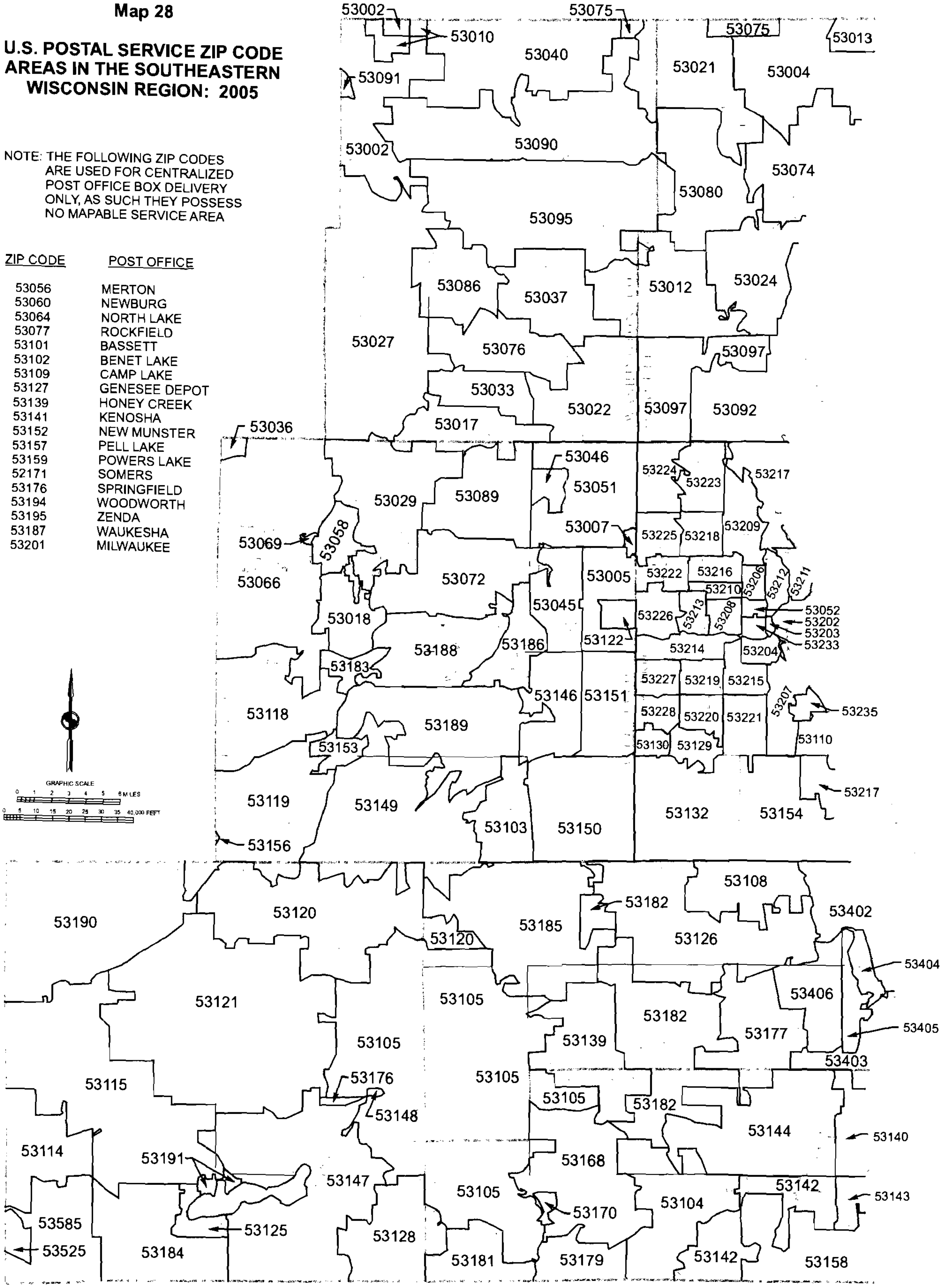
Map 28

U.S. POSTAL SERVICE ZIP CODE AREAS IN THE SOUTHEASTERN WISCONSIN REGION: 2005

NOTE: THE FOLLOWING ZIP CODES ARE USED FOR CENTRALIZED POST OFFICE BOX DELIVERY ONLY, AS SUCH THEY POSSESS NO MAPABLE SERVICE AREA

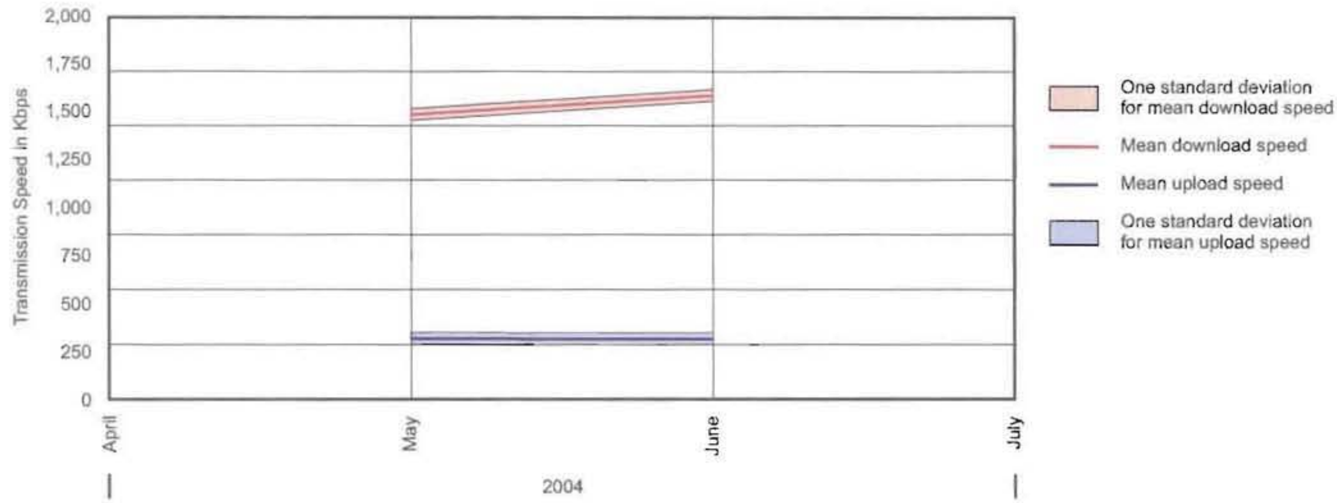
ZIP CODE	POST OFFICE
53056	MERTON
53060	NEWBURG
53064	NORTH LAKE
53077	ROCKFIELD
53101	BASSETT
53102	BENET LAKE
53109	CAMP LAKE
53127	GENESEE DEPOT
53139	HONEY CREEK
53141	KENOSHA
53152	NEW MUNSTER
53157	PELL LAKE
53159	POWERS LAKE
52171	SOMERS
53176	SPRINGFIELD
53194	WOODWORTH
53195	ZENDA
53187	WAUKESHA
53201	MILWAUKEE



Source: *U.S. Census Bureau and SEWRPC.*

Figure 44

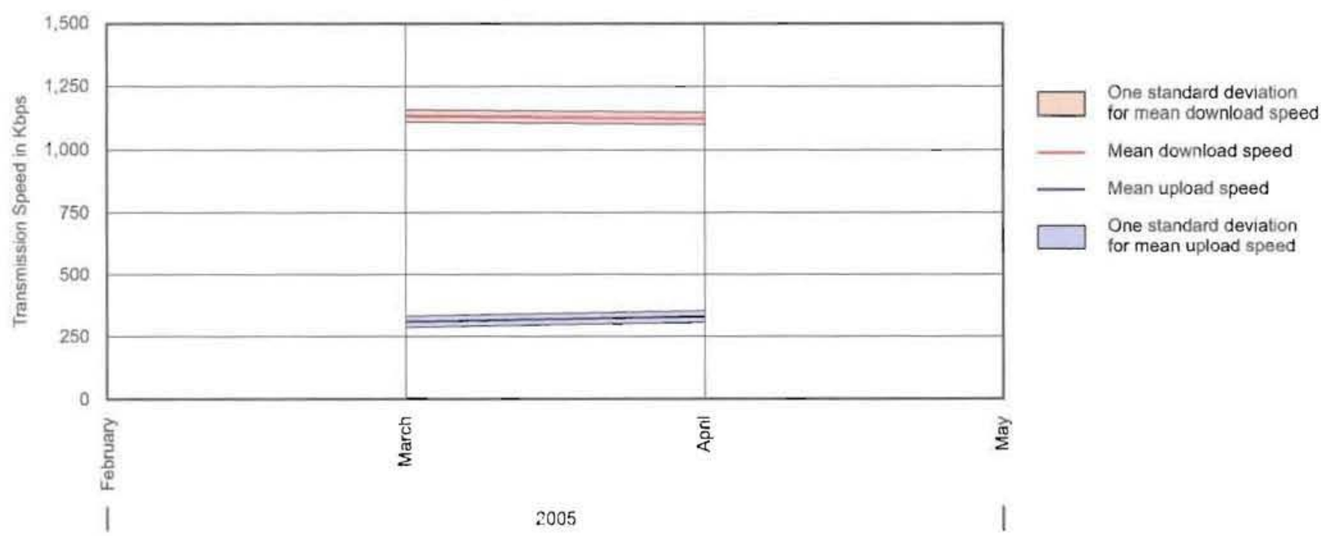
COMPARISON OF DOWNLOAD (1500Kbps) AND UPLOAD (384Kbps) TRANSMISSION RATES BY MONTH FOR SBC – AT&T xDSL IN THE U.S. POSTAL ZIP CODE 53095 AREA OF THE CITY OF WEST BEND, WASHINGTON COUNTY AND ENVIRONS: MAY 2004



Source: Sigma Solutions Group, LLC, and SEWRPC.

Figure 45

COMPARISON OF DOWNLOAD (1500Kbps) AND UPLOAD (384Kbps) TRANSMISSION RATES BY MONTH FOR SBC – AT&T xDSL IN THE U.S. POSTAL ZIP CODE 53207 AREA OF THE NEAR SOUTHSIDE OF THE CITY OF MILWAUKEE: MARCH 2005



Source: Sigma Solutions Group, LLC, and SEWRPC.

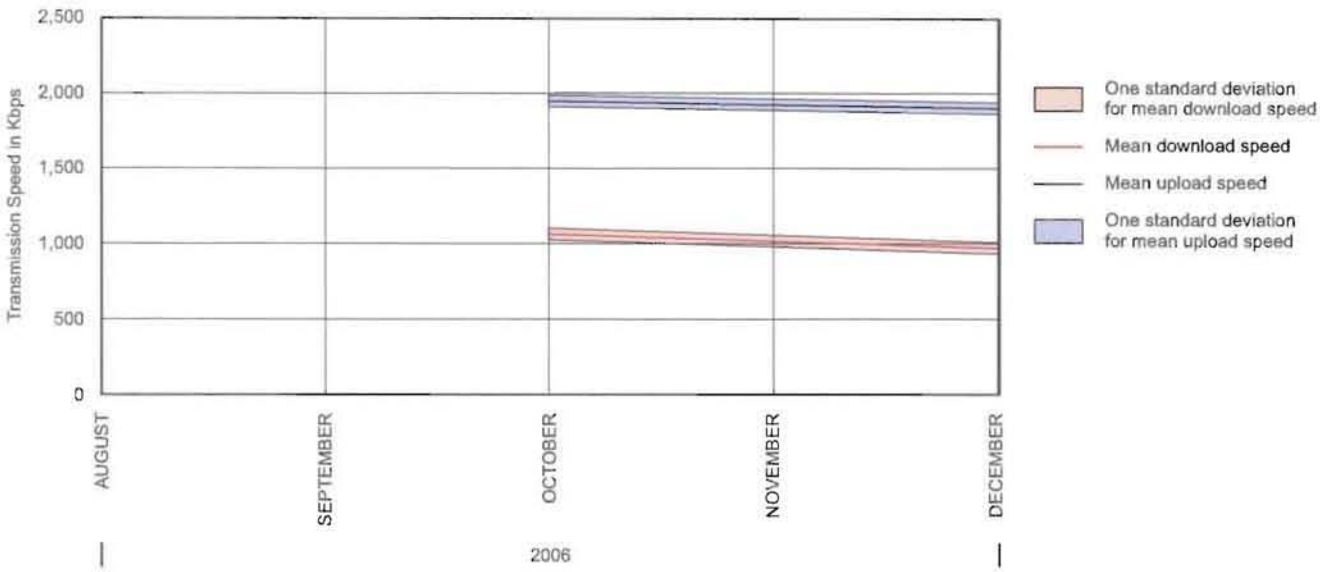
An unusual level of broadband cable network performance is illustrated for the City of Greenfield, Milwaukee County—zip code area 53228 as shown on Map 28—in Figure 46 where the service offering is reversed with greater bandwidth allocated to upload than download transmission (750/3000). Through-put performance appears to be stable over time.

Broadband Communications, Performance Summary

National broadband download wireline throughput performance as measured in megabits per second averages in the 1.0 to 2.5 range in the United States. Upload performance is much slower with recordings around 0.25 to 0.50 megabit per second. This disparity in download versus upload speeds occurs

Figure 46

COMPARISON OF DOWNLOAD (750Kbps) AND UPLOAD (3000Kbps) TRANSMISSION RATES BY MONTH FOR EARTHLINK CABLE IN THE U.S. POSTAL ZIP CODE 53228 AREA OF GREENFIELD, MILWAUKEE COUNTY AND ENVIRONS: OCTOBER 2006 THROUGH DECEMBER 2006



Source: Sigma Solutions Group, LLC, and SEWRPC.

primarily because more bandwidth is generally allocated by the carriers to download traffic. Most user applications such as web search heavily favor download volume. If more bandwidth were allocated to upload traffic, download transmission speeds would be reduced.

Depending on service agreements in terms of maximum download and upload speeds, DSL and cable broadband services are generally equivalent in the one to five megabits per second range at the national level. DSL performance can vary significantly with individual carriers and with the distance of the subscriber from the telephone central office or extended remote terminal. Cable performance also varies between carriers and tends to decline as more subscribers share a common channel in the hybrid fiber coaxial cable network architecture.

Fixed wireless generally offers more symmetrical service offerings in terms of download and upload speeds. Standards based WiFi networks also perform in the one to three megabits per second range. Mobile wireless networks resemble wireline networks in their bias toward much faster download speeds

Although the field measurement studies conducted by the Commission recorded 3G mobile network throughputs well below the two megabits per second targets at 336 kilobits per second, some national data for GSM networks supports throughput above two megabits per second.

Overall, measures of broadband throughput at the State level indicate performance levels in the same range as nationally. Time series recordings of Time Warner Cable, however, display a statewide downward trend in throughput for download traffic. This trend appears to be consistent with the network architecture limitations of hybrid fiber coaxial cable networks. However, Charter Cable performance, while more volatile, does not confirm this downward trend. DSL networks though sensitive to central office distances, do not show this performance reduction from network loading.

Overall measurements of broadband communications networks as provided in Table 16, with thousands of samples, indicate significantly higher performance for cable networks. Average download throughputs for Time Warner and Charter Cable networks are more than double those of telephone DSL networks. It may be concluded from the data summary that broadband cable has an inherently greater bandwidth capability than the current ADSL version of DSL. A smaller sample data summary for a Regional fixed wireless service provider, Netwurx using the Motorola Canopy technology, appears to confirm the broadband capability of fixed wireless in the over one megabit per second range.

Local broadband performance data at the postal zip code area level, where available, are generally consistent with national and Statewide broadband throughput performance data.

Overall, currently available wireline and wireless broadband communications technologies do not provide the throughput performance levels specified in the regional telecommunications service objecttives and standards set forth in Chapter III of SEWRPC Planning Report No. 51, and in Chapter III of this report. In addition, only one of the technologies, DSL, has a current infrastructure development plan aimed at achieving these objectives. AT&T with its Project Lightspeed has targeted line speeds exceeding 20 megabits per second based on a fiber-to-the-node (FTTN/VDSL) technology. Deployment plans, however, currently involve only 25 of the 147 municipalities in the Region, and there is no commitment to serve all of the geographic areas of these communities. There are no publicly available higher throughput broadband plans for the Time Warner or Charter Cable networks.

Fixed wireless in its WiFi version is currently focused on mesh networks which have demonstrated throughput only in the one to three megabits per second range with little upward prospects. Proprietary fixed wireless systems as manufactured by Motorola and Alvarion are operating in the same performance range with no known plans for upward scaling.

WiMAX has been advanced as the standards-based answer to higher performance wireless broadband but current focus in WiMAX is on the mobile version of the technology for licensed spectrum with little activity for the unlicensed bands which provide the basis for most fixed wireless networks. Sprint Nextel has announced plans for the introduction of WiMAX in the United States as a major upgrade of its mobile network with 2008 as a target year. Service level determinations of throughput for the carrier's WiMAX technology are still in the experimental stage.

Chapter VII

DESIGN OF ALTERNATIVE REGIONAL BROADBAND TELECOMMUNICATIONS PLANS

INTRODUCTION

Previous chapters of this report have presented information pertinent to the development of alternative fourth generation (4G) broadband telecommunications plans for Southeastern Wisconsin. The objectives and standards set forth in Chapter III of this report provide the criteria for judging the relative merits of the alternative plans considered, and the rationale for the selection of a recommended plan.

The findings of the existing wireless antennae base station sites within the Region set forth in Chapter V of SEWRPC Planning Report No. 51 provide the basis for selecting antennae station sites for the alternative regional wireless plan. The findings of the service area coverage inventories documented in Chapter V of this report provide the geographic basis for plan design and implementation. The findings of the performance inventory set forth in Chapter VI of this report reveal both the capabilities and shortcomings of current wireline and wireless networks in the Region. These findings also describe the state of current plans for broadband service within the Region, indicating that no single service provider or group of providers have plans for networks that would satisfy the objectives and standards set forth in Chapter III.

Six alternative broadband communications plans were developed and are described and evaluated in this chapter as a basis for the selection of a recommended plan. The recommended plan set forth in Chapter VIII of this report, is a composite of the best features of the alternative plans considered, since no single wireline or wireless communications technology can cost effectively satisfy the needs of all areas of the Region. It is important to understand in this respect, that private sector service providers or governmental organizations could develop different regional broadband communications plans that would satisfy the objectives and standards of Chapter III. The alternative plans presented herein are not intended to impede the development or implementation of plans prepared and put forth by private providers, or by counties or municipalities within the Region, that would move the existing level of telecommunication service within the Region toward the achievement of the agreed upon objectives and standards set forth in Chapter III of this report. It is hoped, however, that the plans herein presented would serve as a point of departure for further telecommunication planning by private providers and public agencies.

The alternative telecommunications plans presented in this chapter represent a mixture of wireline and wireless communications technologies. In designing these alternative plans the cost effectiveness of deploying each technology concerned was taken into account. The alternative plans presented emphasize the access element of communications networks, since this element represents the primary constraint in delivering broadband capability to users. Beyond the direct access networks are the backhaul networks which link primary access networks to core networks which carry the bulk traffic throughout the United States and the remainder of the world. All access communications networks require a core network in order to link with subscribers beyond their immediate areas. The placement of access network node locations is often heavily influenced by the availability of fiber optic gateway locations.

Preparation of a comprehensive broadband regional communications plan involves a sequence of steps that include:

1. Selecting a set of basic communications technologies for consideration in the preparation of alternative plans;

2. Identifying and defining the equipment requirements for both network infrastructure and users to implement the selected technologies;

3. Developing performance data for the various technologies as necessary to determine the estimated performance of alternative plans;

4. Developing capital and operating cost data for the same technologies sufficient to estimate the costs of alternative plans;

5. Preparing geographic network layouts of alternative broadband communications systems with base stations, access points, points of presence, distribution networks and Internet-connecting gateway stations indicated;

6. Specifying the expected performance, benefits and costs associated with each alternative broadband communications system plan; and

7. Evaluating the ability of each alternative plan to meet the objectives and standards set forth in Chapter III of this report as a basis for selecting a recommended broadband communications system plan for the Region.

The end result of this sequence of design activities is a proposed regional broadband communications network infrastructure, set forth in the succeeding chapter of this report, that will support a wide variety of broadband users with a fourth generation (4G) communications deployment.

TECHNOLOGICAL ALTERNATIVES

Five separate but related technological alternatives were considered in formulating alternative broadband telecommunications plans for the Region:

1. <u>Community-Based Advanced WiFi Wireless Networks</u>
   This plan is based on extended range versions of IEEE Standard 802.11g operating in the 2.40 to 2.48 GHz band, and is intended to serve fixed and nomadic users.

2. <u>Regional Advanced WiFiA Wireless Network</u>
   This plan is based on IEEE Standards 802.11a (WiFiA) operating in the 5.8 GHz band, and is intended to serve fixed and nomadic users.

3. <u>Regional Mobile WiMAX-based Wireless Network</u>
   This plan is based on IEEE Standard 802.16e and is intended to serve mobile users.

4. <u>Regional Fiber-to-the Node Wireline Network</u>
   This plan would provide fiber optic cable from telephone system central offices to remote nodes, and twisted pair copper wires from the nodes to each user. The plan would be based on VDSL technology.

5. <u>Localized Fiber-to-the Premises, Wireline Network</u>
   This plan would provide fiber optic cable to each premise in areas with sufficient population and/or enterprise densities to justify the investment required.

Advanced WiFi Wireless and WiMAX Technologies

Information on the history and general background of IEEE Standard 802.11 (WiFi for Wireless Fidelity) were provided in SEWRPC Planning

Report No. 51, and will not be repeated here. It is important however, to emphasize the advanced high performance version of the WiFi technology proposed to be employed in the plans. Traditional WiFi networks operate around very short range—300 feet radius—access points—hot spots—in homes, coffee shops, hotels, schools and other designated locations. The WiFi networks planned here feature a sectoral cellular network topology and high gain active antennas at each fixed user premise. This combination of network structure and augmented user transceiver equipment allows for 4G levels of network throughput performance exceeding 20 megabits per second. Community-level WiFi access networks would operate using the 802.11g standard at 2.4 GHz with 802.11a backhaul at 5.8 GHz, while regional networks would operate with the 802.11a standard and for backhaul.

Initial releases of WiMAX equipment are expected to be in the licensed bands such as 2.5 GHz and 3.5 GHz. Such bands are available only to licensed carriers who have purchased radio spectrum from the Federal Government. Such licensed bands are expected to be used primarily for mobile communications. Succeeding WiMAX equipment releases, however, are expected to be at 5.8 GHz, an unlicensed band suitable for backhaul communications as defined here. WiMAX equipment for backhaul infrastructure deployment will be more costly of equivalent WiFiA (802.11a) equipment operating in the 5.8 GHz band. The improved quality of service features and traffic handling capability of WiMAX is expected to justify the increased cost.

Mobile WiMAX Technologies

The WiMAX technology referenced in the previous section is specified for fixed backhaul networks. Another version of WiMAX 802.16e is being developed for mobile use. This WiMAX version differs in its ability to serve users in moving vehicles rapidly crossing sectoral boundaries and requiring rapid handoffs to adjacent access points. This version of WiMAX is also able to service fixed and nomadic users, but generally at slower data rates than fixed WiFi/WiMAX networks. In mobile application, the potential advantage of WiMAX over current 3G versions of GSM/UMTS and CDMA/EV-DO technologies is the provision of higher data rates with the potential at least of 4G-level performance of 20 megabits per second or better. Early deployments of mobile WiMAX are expected to be data centric to take advantage of the higher throughput performance of this technology. WiMAX also will have more advanced quality of service (QOS) capabilities with a more sophisticated media access protocol than current WiFi networks.

Because mobile WiMAX technology will be available, at least initially, only in licensed bands such as 2.5 GHz and 3.5 GHz, regional deployment of mobile WiMAX will depend on the selection of this technology by licensed American wireless carriers. To date, Sprint/Nextel is the only American wireless carrier committed to WiMAX. WiMAX plans, then, must be based on a Sprint/Nextel regional deployment. The timing of such a Southeastern Wisconsin mobile WiMAX deployment will depend upon corporate priorities concerned. Sufficient information on both WiMAX technology and the current Sprint/Nextel base station infrastructure, however, is available to prepare a 802.16e WiMAX plan for the Region. In fact, the antenna site information obtained from Sprint and Nextel was considered to be complete and of high quality. These two service providers were the only providers that cooperated in the Commission regional antenna site inventory.

Fiber-to-the-Node Wireline Technologies

The Fiber-to-the-Node (FTTN) technology to be employed in the broadband wireline communications plan of the same name is the Alcatel-based technology currently being used by AT&T to deploy the U-Verse system as part of Project Lightspeed in Southeastern Wisconsin. The reasons for selecting the particular version of FTTN are two:

1. <u>State of the Art Technology</u>
   This particular Alcatel-based version of FTTN is a current, well-conceived and carefully reviewed technology.

2. <u>AT&T – Major Incumbent Local Exchange Carriers (ILEC) in the Region</u>
   As the dominant ILEC in Southeastern Wisconsin, AT&T owns most of the copper lines required to implement any FTTN wireline plan. Under Federal law, AT&T must make these copper lines available to other facilities-based service providers. The

AT&T must lease space in AT&T central offices to other providers; those providers may then install their own fiber optic cable connections from the central offices concerned to remote nodes; and the AT&T must then make their copper line distribution facilities available for use by the other providers under appropriate lease agreements. Any FTTN plan applying to areas beyond the AT&T service areas must be based on ILEC carriers that own copper distribution lines to homes, businesses, and institutions. FTTN extensions beyond AT&T service areas were, therefore, presumed to be deployed by other ILEC's operating within the Region such as Century Tel and Verizon North.

The AT&T FTTN broadband communications network is based on Alcatel's 7330 Intelligent Services Access Manager, ISAM. The 7330 ISAM is connected by fiber optic cable with the local central office and serves as a remote distribution point for broadband traffic to users over existing twisted pair copper links. Each ISAM can service subscribers located within a 3,000 feet radius of the node. High speed throughput is possible because the signal-to-noise ratio (SNR), which decreases with distance from the node, is still high enough to support throughputs exceeding 20 megabits per second.

A pictorial diagram of a U-Verse network is shown in Figure 47. Supporting the node and local central offices are a series of special central offices that manage Internet access and Voice over IP as well as video. Regional IP video hub offices store and distribute video content to end users through local central offices.

Physically, the U-Verse network takes the form of a set of outdoor cabinets as shown in Figure 48. Three cabinets are typically located at each node location:

1. Fiber Conversion Cabinet
   This cabinet houses the Alcatel 5330 ISAM, with 200, 400 or 800 line connections, the corresponding cabinets being designated as 52 BP, 52B or 52E respectively.

2. Power Cabinet
   This cabinet houses power line connections, power supply equipment and power metering.

3. Cross Connection Cabinet
   This cabinet serves as a cross-connection point for subscriber twisted pair copper lines.

It should be emphasized that U-Verse represents a further stage upgrade to AT&T's original Digital Subscriber Line (DSL) broadband offering as shown in Figure 49. The original ADSL deployment was based on copper line connections to a central office. The central office is able to serve DSL subscribers within a radius of about 18,000 feet of a central office. The first upgrade, shown just below the all-copper existing network in Figure 49, deployed fiber-linked remote terminals that extended DSL range to a new radius of 18,000 feet from the remote terminal. This upgrade brought DSL services to areas previously located too distant from central offices. The second upgrade, shown in the lower part of Figure 49, is the U-Verse upgrade now part of the current Project Lightspeed (VDSL). Because the new high speed VDSL technology is limited to a 3,000 foot radius, this upgrade will require a much higher density of remote nodes than the original ADSL remote terminals.

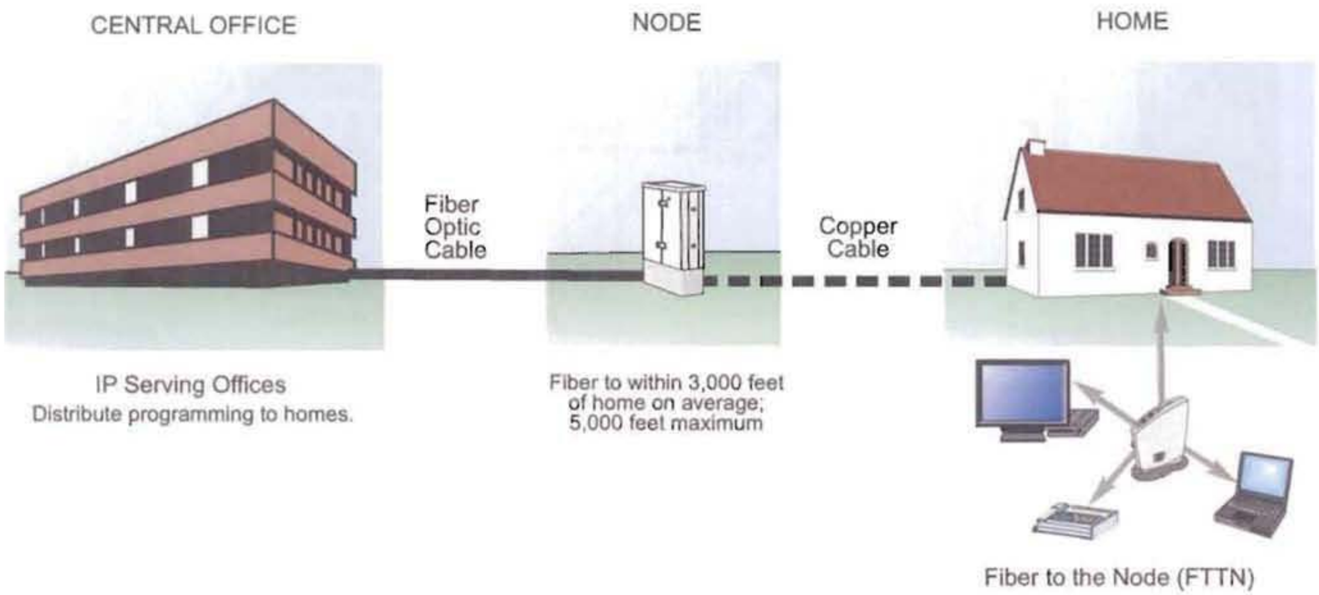
Achieving the data rates of 20 to 25 megabits per second needed for high definition television represents a significant challenge for copper-based networks. An important component in achieving these high data rates is video compression technology. Alcatel and AT&T are relying on significant improvements in the current MPEG-4 video compression technology to satisfy their target markets.

Localized Fiber-to-the-Premises (FTTP) Wireline Technology

Fiber optic cable technology represents the ultimate in bandwidth for broadband communications systems. A single-mode fiber strand using the most sophisticated fiber transceiver technology has currently an ultimate demonstrated capacity of 14 terabits per second, where a terabit per second is equal to 1,000 gigabits per second. A gigabit per second in turn represents a 1,000 megabits per second. Fiber optic transmission systems of such

Figure 47

FIBER TO THE NODE WIRELESS TELECOMMUNICATION TECHNOLOGY



Source: AT & T and SEWRPC.

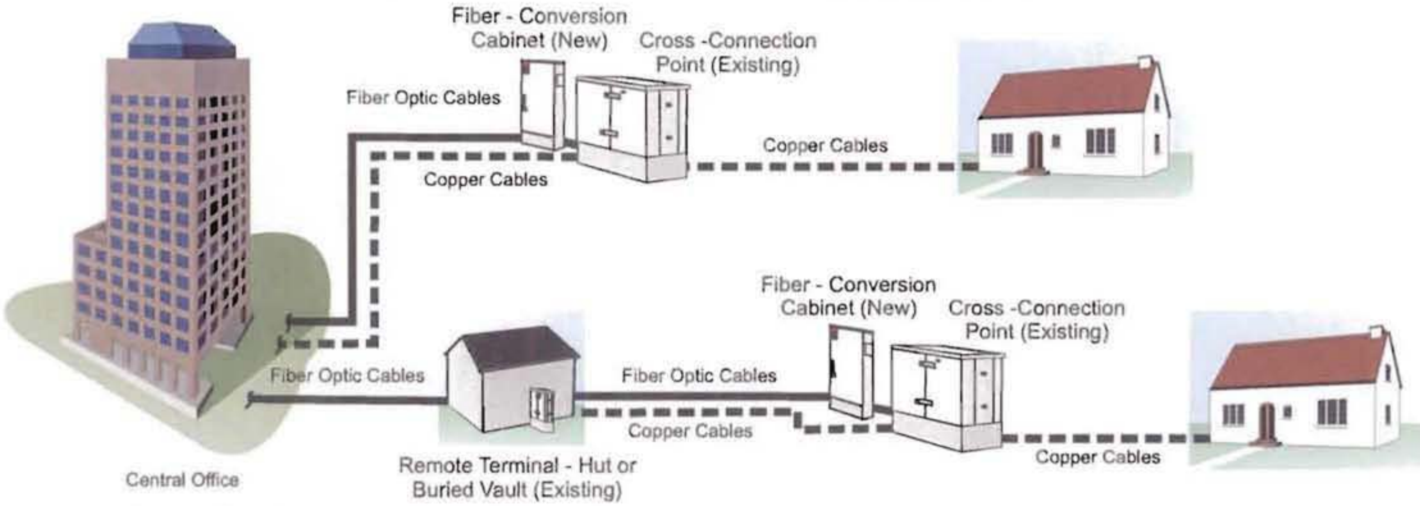
Figure 48

TYPICAL INTELLIGENT SERVICE ACCESS MANAGER (ISAM)

Source: AT & T and SEWRPC.

Figure 49

EVOLUTION OF NETWORK FROM DIGITAL SUBSCRIBER LINE (DSL) SERVICE TO FIBER TO THE NODE SERVICE



Source: AT & T and SEWRPC.

capacity are deployed only on major trunk lines such as transoceanic links. Economic cost and need considerations result in lower capacity networks for user broadband access.

Two major technologies are utilized in fiber optic access networks; Active Optical Networks (AONs) and, Passive Optical Networks (PONs).

Active optical networks require a dedicated fiber from a central office to each user with transceiver electronic equipment at both ends of the connection. In an AON network, throughput is limited only by the cost and complexity of the transceiver equipment at both ends of the connection. The fiber strand itself, as already noted, has essentially unlimited bandwidth. Cost considerations, however, do limit the capacity of the transceiver equipment to data rates in the lower gigabit range.

Passive optical networks share both optical fiber and transceiver equipment. With the Alcatel 7340 Fiber-to-the-Premises (FTTP) System employed regionally by AT&T, a single fiber connects multiple users to a single transceiver located at a central office. The single fiber is split, using a passive optical splitter, to serve up to 32 users. The PON approach reduces not only the amount of fiber required, but also the electronic transceiver equipment, lowering both capital and operating costs for the service provider. AT&T Wisconsin has selected the PON design alternative to take advantage of these lower capital and operating costs. The disadvantage of this determination is in the lower throughput potential of a PON as compared to an AON system configuration. The Alcatel 7340 PON system selected by AT&T will provide Internet access data rates up to 100 megabits per second. While this data rate is significantly above data rates possible with AT&T's ADSL service, or even Fiber-to-the-node (FTTN) technology, it is also below the ultimate potential of fiber optic broadband service which lies well into the gigabit per second range. Broadband service of 100 megabits per second however, complies with the 4G objective and standards set forth in Chapter IV of this report. In the future, this network capacity may be challenged by the needs of video-on-demand. A network diagram of the Alcatel 7340 FTTU System is shown in Figure 50. The system is comprised of the following functional components:

At the Central Office

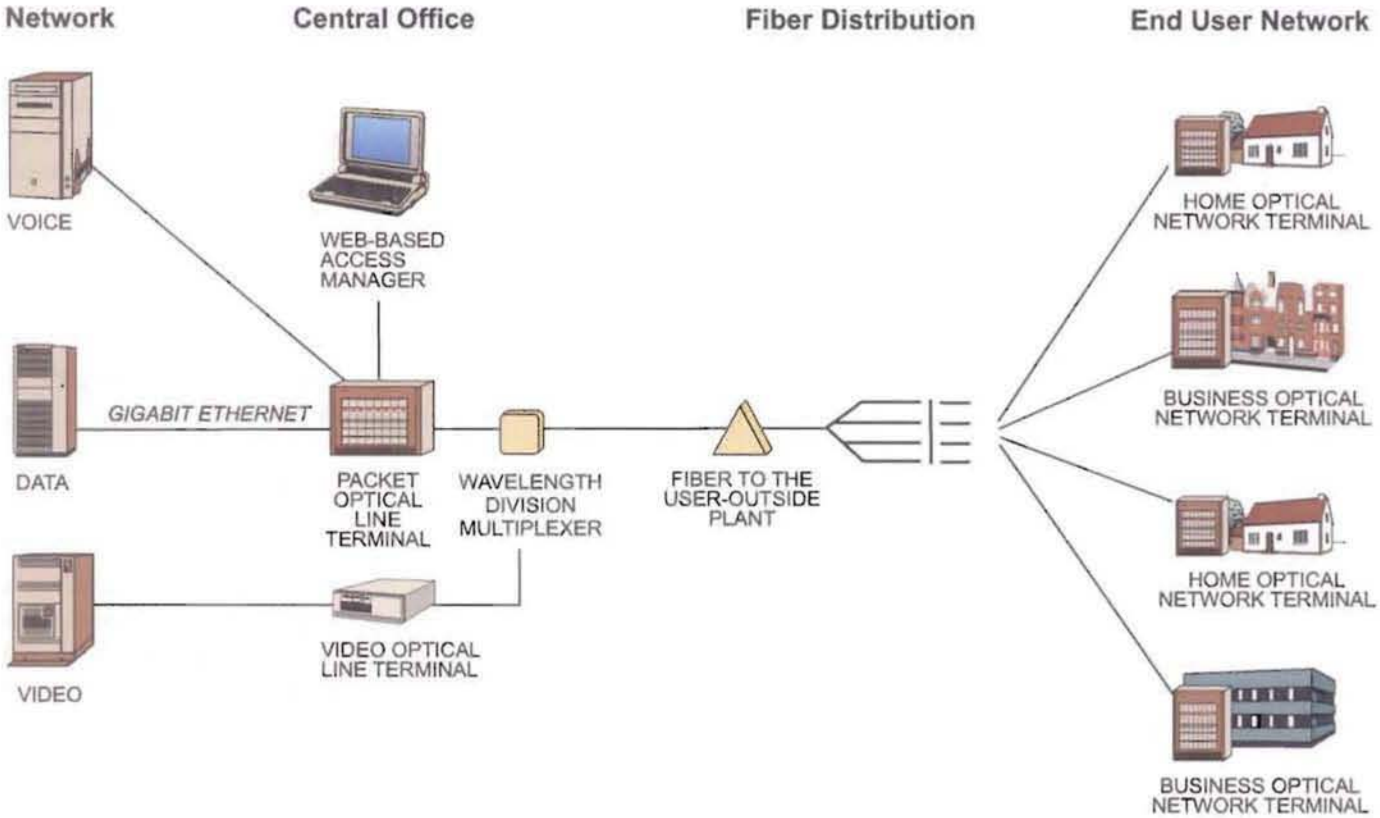
1. <u>Packet Optical Line Terminal (P-OLT)</u>
   This component serves data and voice traffic.

2. <u>Video Optical Line Terminal (V-OLT)</u>
   This component serves video traffic.

3. <u>Web – based Access Manager (WAM)</u>
   This component provides local network management.

Figure 50

FIBER TO THE PREMISES NETWORK DIAGRAM



Source: ALCATEL and SEWRPC.

4. Wavelength – Division Multiplexer
   This component provides frequency multiplexing on the fiber optic link.

In the Field

1. Alcatel 6620 Outside Plant
   This component consists of fiber optic cable, splicing enclosures for patching, coupling and optical splitters.

User Premises

1. Home Optical Network Terminal (H-ONT)
   This component terminates the PON fiber optic cable at the residence and provides voice, data and video interfaces.

2. Business Optical Network Terminal (B-ONT)
   This components terminates the PON fiber optic cable at the business site and provides voice, data and video interfaces.

The Alcatel 7340 FTTU System supports a long distance reach of up to 12.4 miles from the central office. The P-OLT collects voice traffic and routes it to a voice gateway. Data traffic is accrued and routed to a broadband switch or router also by the P-OLT at the central office. In a similar manner, video traffic is directed through the V-OLT where it is amplified for downstream or upstream transmission.

For reasons similar to those presented for the fiber-to-the-node wireline technologies, this particular version of Alcatel FTTU technology was selected for the regional wireline plan. It is the choice of AT&T, the major ILEC in the Region. While legacy home or business copper lines are no longer involved in this technology, the major capital commitments required to implement the technology makes the technology of the major ILEC an important consideration.

ALTERNATIVE PLANS

Employing the wireless and wireline technologies just described, six alternative broadband telecommunications plans were developed as candidates for the recommended regional plan. Four of these plans employ wireless broadband technologies and two employ fiber optic wireline technologies. Since no one technology is likely to fulfill all of the functional needs—fixed, nomadic and mobile users—and all of the geographic constraints—urban, suburban and rural area—the final regional comprehensive broadband telecommunications plan is a composite of the functional capabilities and geographic components of a number of the alternative wireless or wireline broadband communications plans.

The following six alternative broadband communications plans are presented in this chapter:

1. Community-Based Wireless Plan
   Under this plan advanced WiFi/WiMAX wireless networks would be provided on a community-by-community basis with the option of a WiMAX-based backhaul network for fixed and nomadic users. With some minor changes in associated hardware and software, this alternative is the wireless plan presented in SEWRPC Planning Report No. 51.

2. Regional Wireless Plan
   Under this alternative plan all areas of the Region would be served by an integrated WiFiA wireless network with fiber optic gateways provided at each base station site for fixed and nomadic users.

3. Mobile WiMAX-based Wireless Plan
   This plan is based on IEEE Standard 802.16e, and would use licensed frequency bands in the 2.5 or 3.5 GHz spectral regions to provide high data rate cell phone service to the entire Region.

4. Mobile Wi-Fi-based Wireless Plan
   This plan is based upon IEEE Standard 802.11a and 802.20, and would use unlicensed frequencies in the 5.8 GHz band to provide high data rate cell phone service as an extension of the Alternative Plan 2, the Regional Wireless Plan.

5. Regional Fiber-to-the-Node (FTTN) Wireline Plan
   This plan is based upon Alcatel 7330 FTTN technology, and would extend fiber optic cable from telephone system central office locations to remote sites for copper line transmission to users. The plan would employ very high speed VDSL technologies.

6. Regional Fiber-to-the-Premises (FTTP) Wireline Plan
   This plan is based on Alcatel 7340 FTTU technology, and would extend fiber optic cable to each user's premises using Passive Optical Network (PON) technology.

Community-Based Wireless Plan

As already noted, the community-based wireless plan is substantially the plan presented in SEWRPC Planning Report No. 51, *A Wireless Antenna Siting and Related Infrastructure Plan for Southeastern Wisconsin,* September 2006. Differences relate only to additional equipment and related software options for the end user and an alternative approach to servicing nomadic users in community-based wireless networks. These additions and alternatives are described below as a part of a brief review of the structure of this plan as presented in SEWRPC Planning Report No. 51.

The regional community-based wireless plan consists of two major mutually supportive networks: a regional wireless backhaul network and a set of community level wireless service plans.

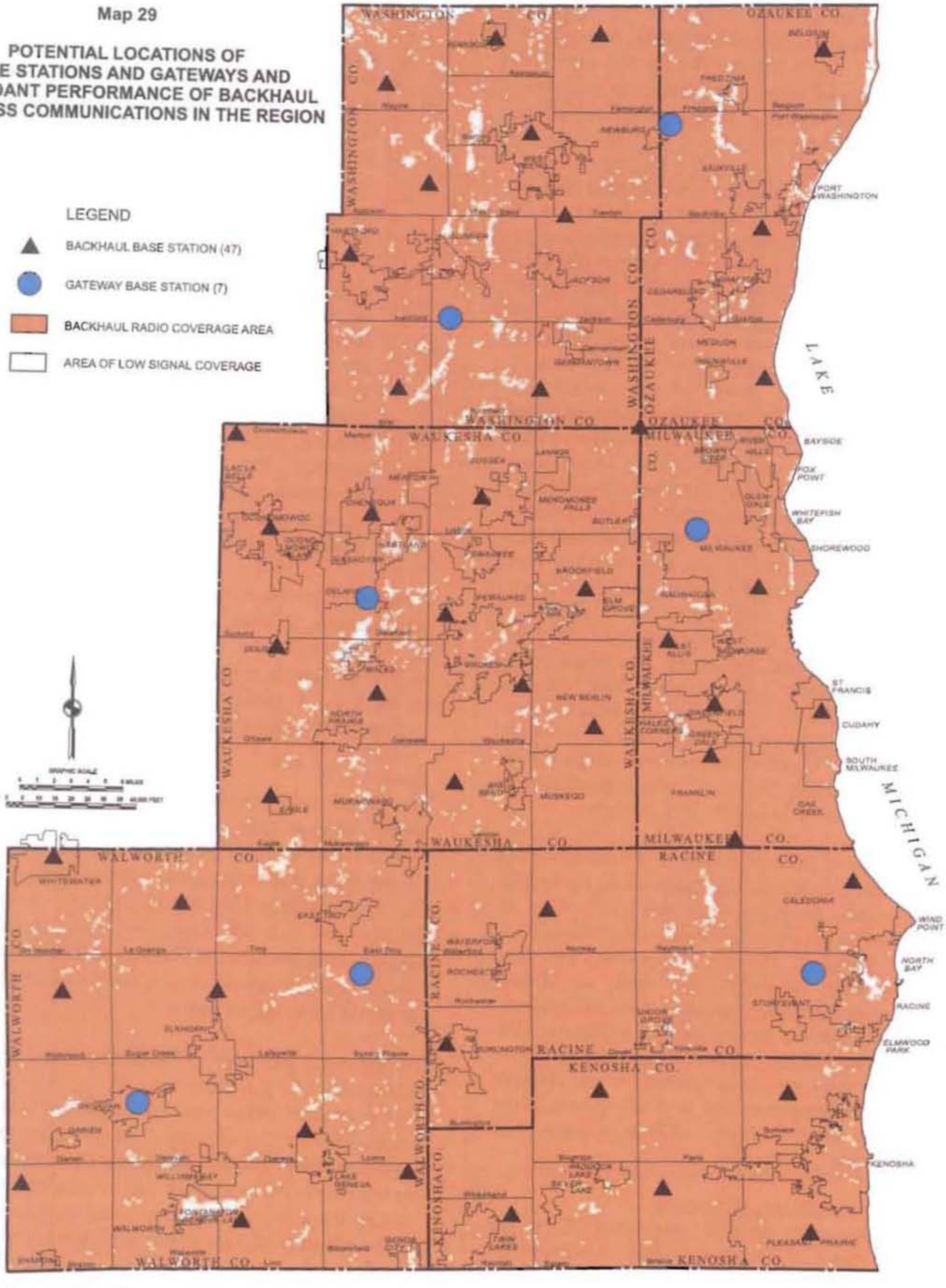
The Regional Wireless Backhaul Network Plan is fully described on pages 195 to 199 of SEWRPC Planning Report No. 51 previously referenced. The description includes Map 60 on page 196 which shows all 47 backhaul base stations and the 7 recommended gateway stations required to service all potential community-based wireless networks in the Region. This Plan map is provided as Map 29 in this Chapter. While all communities will have the option of arranging for their own Internet gateway connections, most would benefit financially by interconnecting to a regional wireless backhaul network. The alternative WiFiA and WiMAX technologies to be used in building the wireless backhaul infrastructure are also described in SEWRPC Planning Report No. 51.

Map 29

POTENTIAL LOCATIONS OF BASE STATIONS AND GATEWAYS AND ATTENDANT PERFORMANCE OF BACKHAUL WIRELESS COMMUNICATIONS IN THE REGION

LEGEND

- ▲ BACKHAUL BASE STATION (47)
- ● GATEWAY BASE STATION (7)
- BACKHAUL RADIO COVERAGE AREA
- AREA OF LOW SIGNAL COVERAGE



Source: SEWRPC.

Summary costs for deploying the backhaul network infrastructure are provided on page 197 of SEWRPC Planning Report No. 51 and detailed in Appendix F of that report. Costs are provided for both new and existing co-located sites. Estimated operating costs of the regional backhaul network are detailed in Appendix G of that report.

Individual community level wireless plans would be prepared by the Commission, or by consultants or potential providers, upon request of the local unit or units of government concerned. An example of a community wireless plan for an urban area of the Region—for the City of Cedarburg and Village of Grafton area of Ozaukee County—is presented in SEWRPC Planning Report No. 51. This plan is based on advanced WiFi 802.11g technology included in the detailed plan description on pages 199 to 204 of the report. Maps 61 and 62 on pages 200 and 201 of that report depict a 41 access point structure with 18 in the City of Cedarburg and 23 in Village of Grafton servicing both fixed and nomadic users. Map 61 on page 200 of that report indicates anticipated performance levels for nomadic users and Map 62 on the page following for fixed users. These plan maps are provided as Maps 30 and 31 in this Chapter. Table 67 on page 202 lists all of the recommended access points for the Cedarburg-Grafton community wireless plan. This table is provided as Table 17 in this Chapter. Infrastructure capital costs and system operating costs are provided in Appendices F and G respectively of SEWRPC Planning Reporting No. 51. These appendices are provided as Tables 18 and 19 in this Chapter.

Since the publication of SEWRPC Planning Report No. 51 the Commission has been asked by several municipalities to prepare second level plans as envisioned in the plan implementation procedure set forth in SEWRPC Planning Report No. 51. The requests have involved both rural and urban communities. The preparation of these second level plans has involved the conduct of extensive field tests of the initially proposed networks, and the findings of these tests have resulted in some changes to and enhancements of the original network plans for the areas concerned. These changes and enhancements include:

1. User Premises Equipment
   Previously, potential users were offered the option of installing either a directional antenna or a directional antenna with a high gain preamplifier.

2. Repeater Sites and Nomadic Users
   Previously, the wireless network plans were prepared separately for two classes of users—fixed users and nomadic users. Plans servicing nomadic as well as fixed users typically required a larger number of access points to provide the same level of performance. A new wireless network design approach using lower cost repeater sites will significantly lower the overall cost of a system configured to serve nomadic users. A repeater site is estimated to cost about 30 percent of the cost of a primary access point, and the repeaters can be selectively placed in locations where nomadic user performance upgrades are required. This repeater-based network enhancement can be accomplished without changing the network access point structure originally placed to serve only fixed users.

With the exception of the afore listed changes and enhancements, Alternative Plan One is identical to the community-based wireless plan described in SEWRPC Planning Report No. 51 and is intended to be used as a model for any community-based wireless plans that may be prepared.

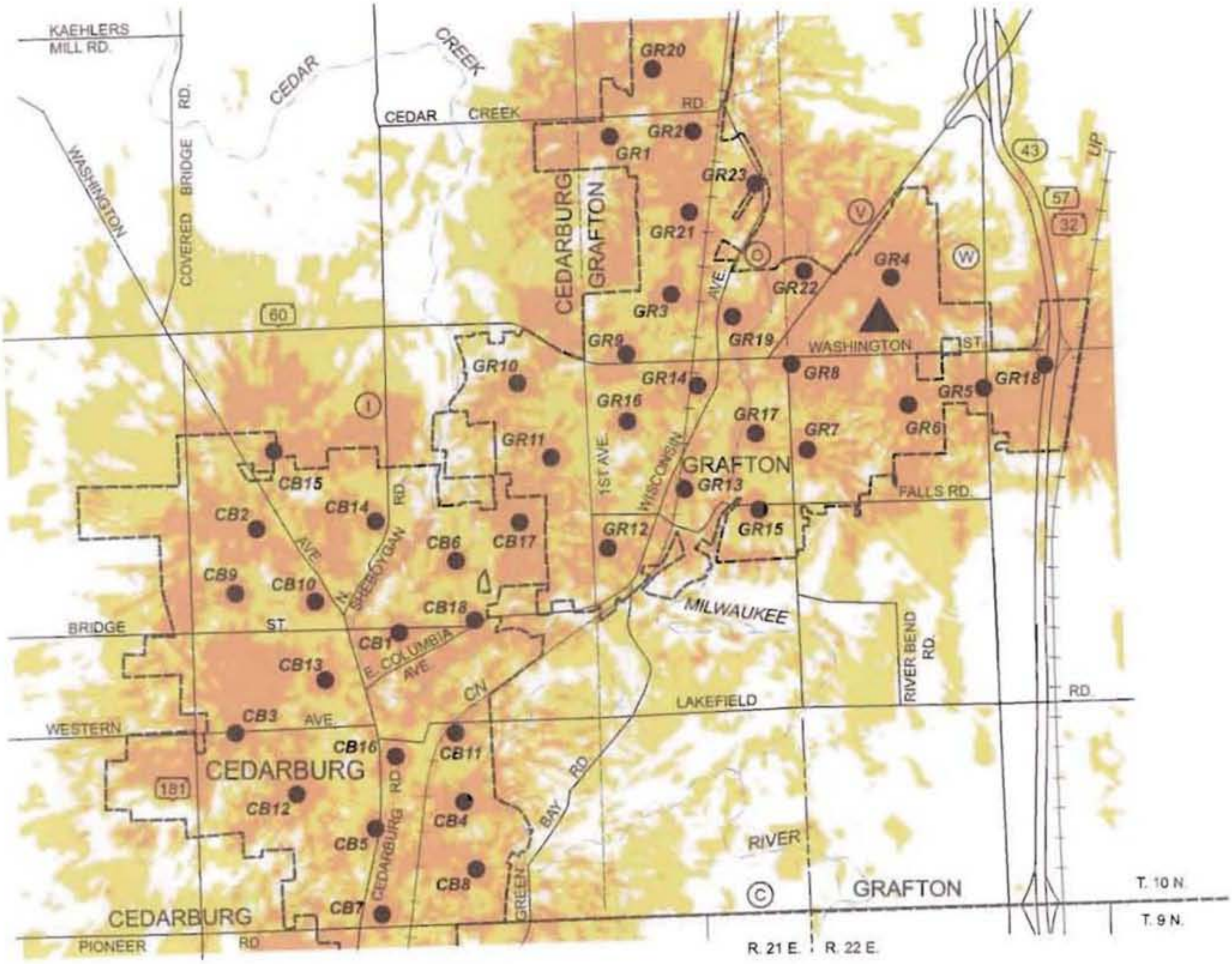
Costs

The infrastructure capital cost for an urban community wireless plan are typified by the wireless plan for the Cedarburg-Grafton area of Ozaukee County. The cost of the access infrastructure of this plan is estimated at $353,000 for 41 access points in the required network. Operating costs for each access point, as detailed in Table 19, are estimated at about $37 per month per station, or about $1,500 per month for all 41 access points.

To estimate the cost of providing the access infrastructure for the Region as a whole, the cost for the Cedarburg-Grafton area were expanded utilizing a regional multiplier of 57.5. This multiplier represents the ratio of the Cedarburg-Grafton urban service area to the total urban service area within the Region, the urban service areas being approximated by the adopted sanitary sewer service areas within

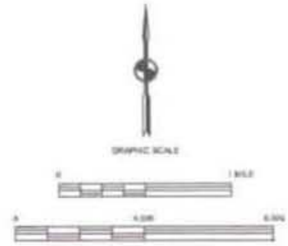
Map 30

POTENTIAL LOCATIONS OF WIFI ACCESS POINTS AND ATTENDANT PERFORMANCE OF ACCESS NETWORK FOR NOMADIC USERS IN THE CEDARBURG-GRAFTON AREA: BASE STATION TO USER



LEGEND

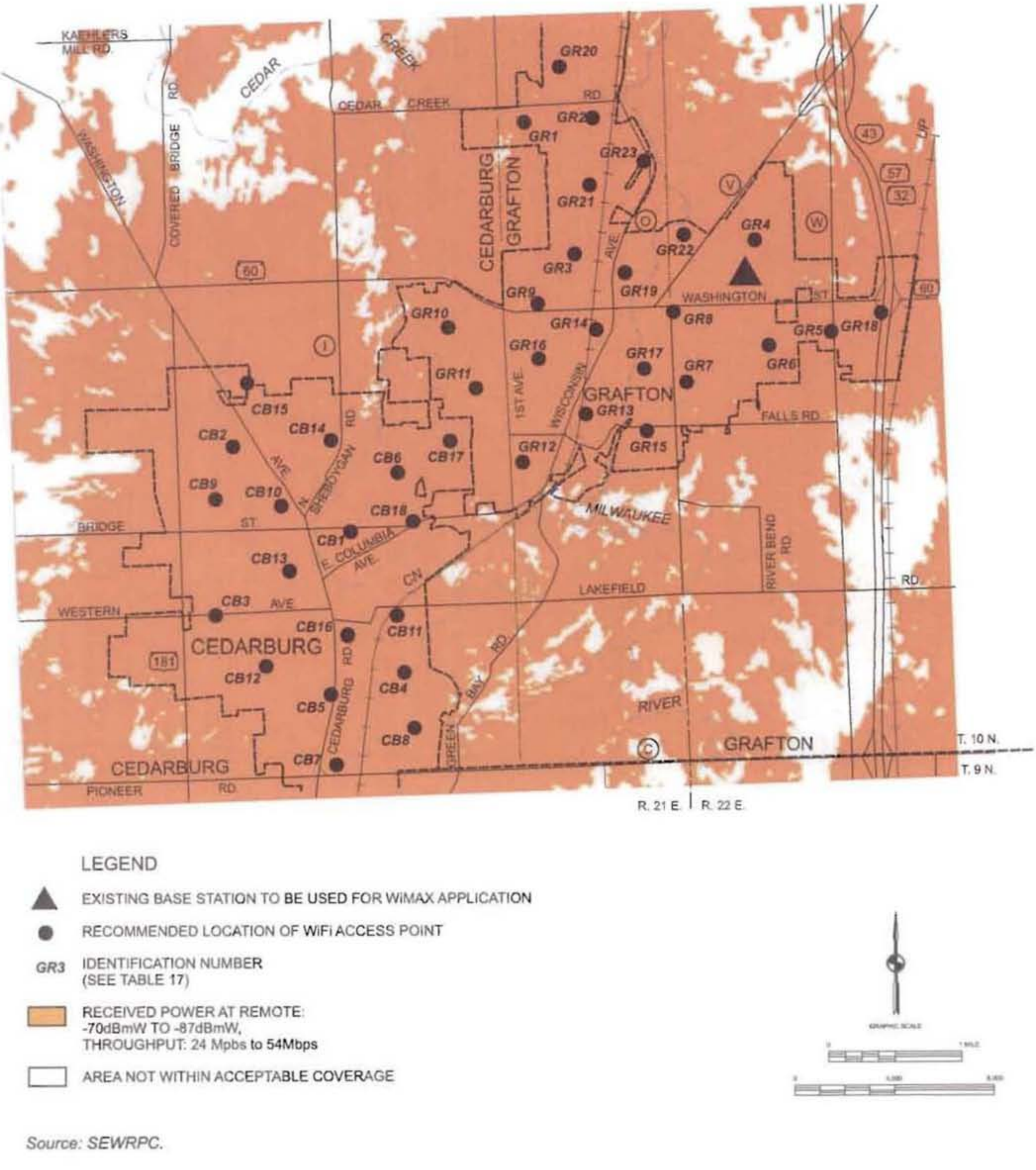
- EXISTING BASE STATION TO BE USED FOR WiMAX APPLICATION
- RECOMMENDED LOCATION OF WiFi ACCESS POINT
- *GR3* IDENTIFICATION NUMBER (SEE TABLE 17)
- RECEIVED POWER AT REMOTE: -70dBmW TO -79dBmW, THROUGHPUT: 24 Mbps to 54Mbps
- RECEIVED POWER AT REMOTE: -79dBmW to -87dBmW, THROUGHPUT: 6 Mbps to 24 Mbps
- AREA NOT WITHIN ACCEPTABLE COVERAGE



Source: SEWRPC.

Map 31

POTENTIAL LOCATIONS OF WIFI ACCESS POINTS AND ATTENDANT PERFORMANCE OF ACCESS NETWORK FOR FIXED USERS IN THE CEDARBURG-GRAFTON AREA: BASE STATION TO REMOTE



Source: SEWRPC.

Table 17

LOCATIONS OF RECOMMENDED WIRELESS ACCESS POINTS TO BE USED FOR WiFi PURPOSES IN THE CITY OF CEDARBURG AND VILLAGE OF GRAFTON, OZAUKEE COUNTY, WISCONSIN

Site Number (See Maps 30,31, and 37)	Location			
	State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Civil Division
	North	East		
GR1	493,567	2,542,022	T. 10 N., R. 21 E. Sec. 13	Village of Grafton
GB2	488,807	2,545,318	T. 10 N., R. 21 E. Sec.13	Village of Grafton
GR3	489,372	2,543,603	T. 10 N., R. 21 E. Sec. 13	Village of Grafton
GR4	489,971	2,549,446	T. 10 N., R. 22 E. Sec. 18	Village of Grafton
GR5	486,743	2,551,950	T. 10 N., R. 22 E. Sec. 19	Village of Grafton
GR6	486,450	2,549,905	T.10 N., R. 22 E. Sec. 19	Village of Grafton
GR7	485,296	2,547,322	T. 10 N., R. 22 E. Sec. 19	Village of Grafton
GR8	487,628	2,546,826	T. 10 N., R. 22 E. Sec. 19	Village of Grafton
GR9	487,928	2,542,530	T. 10 N., R. 21 E. Sec. 24	Village of Grafton
GR10	487,149	2,539,665	T. 10 N., R. 21 E. Sec. 23	Village of Grafton
GR11	485,188	2,540,599	T. 10 N., R. 21 E. Sec. 23	Village of Grafton
GR12	482,694	2,541,918	T. 10 N., R. 21 E. Sec. 25	Village of Grafton
GR13	484,267	2,544,017	T. 10 N., R. 21 E. Sec. 24	Village of Grafton
GR14	487,002	2,544,322	T. 10 N., R. 21 E. Sec. 24	Village of Grafton
GR15	483,683	2,545,926	T. 10 N., R. 21 E. Sec. 25	Village of Grafton
GR16	485,980	2,542,482	T. 10 N., R. 21 E. Sec. 24	Village of Grafton
GR17	485,633	2,545,878	T. 10 N., R. 21 E. Sec. 26	Village of Grafton
GR18	487,463	2,553,785	T. 10 N., R. 21 E. Sec. 26	Village of Grafton
GR19	488,807	2,545,318	T. 10 N., R. 21 E. Sec. 24	Village of Grafton
GR20	495,301	2,543,229	T. 10 N., R. 21 E. Sec. 12	Village of Grafton
GR21	491,564	2,544,215	T. 10 N., R. 21 E. Sec. 13	Village of Grafton
GR22	490,090	2,547,290	T. 10 N., R. 22 E. Sec. 18	Village of Grafton
GR23	492,355	2,546,028	T. 10 N., R. 21 E. Sec. 13	Village of Grafton

Site Number (See Maps 30,31, and 37)	Location			
	State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Civil Division
	North	East		
CB1	480,488	2,536,424	T. 10 N., R. 21 E. Sec.26	City of Cedarburg
CB2	483,338	2,532,805	T. 10 N., R. 21 E. Sec. 27	City of Cedarburg
CB3	477,856	2,532,271	T. 10 N., R. 21 E. Sec. 34	City of Cedarburg
CB4	475,954	2,538,218	T. 10 N., R. 21 E. Sec. 25	City of Cedarburg
CB5	475,207	2,535,812	T.10 N., R. 21 E. Sec. 24	City of Cedarburg
CB6	482,317	2,537,883	T. 10 N., R. 21 E. Sec. 26	City of Cedarburg
CB7	473,063	2,535,915	T. 10 N., R. 21 E. Sec. 34	City of Cedarburg
CB8	474,070	2,538,428	T. 10 N., R. 21 E. Sec. 35	City of Cedarburg
CB9	481,530	2,532,094	T. 10 N., R. 21 E. Sec. 27	City of Cedarburg
CB10	481,367	2,534,206	T. 10 N., R. 21 E. Sec. 27	City of Cedarburg
CB11	477,791	2,537,969	T. 10 N., R. 21 E. Sec. 35	City of Cedarburg
CB12	476,276	2,533,937	T. 10 N., R. 21 E. Sec. 34	City of Cedarburg
CB13	479,193	2,534,415	T. 10 N., R. 21 E. Sec. 27	City of Cedarburg
CB14	483,477	2,535,790	T. 10 N., R. 21 E. Sec. 27	City of Cedarburg
CB15	483,417	2,533,281	T. 10 N., R. 21 E. Sec. 22	City of Cedarburg
CB16	477,206	2,536,337	T. 10 N., R. 21 E. Sec. 24	City of Cedarburg
CB17	483,309	2,539,755	T. 10 N., R. 21 E. Sec. 26	City of Cedarburg
CB18	480,689	2,538,419	T. 10 N., R. 21 E. Sec. 26	City of Cedarburg

[a] *State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.*

Source: SEWRPC.

Table 18

ANTENNA AND RELATED INFRASTRUCTURE COST ESTIMATES FOR THE CEDARBURG-GRAFTON AREA WIRELESS NETWORK PLAN

COMMUNITY WiFi NETWORK (802.11) ACCESS POINT EQUIPMENT

WiFi (802.11 a,g) Access Point		
1.	Transceiver Modules	
	2 at $1,500 =	$3,000
2.	Sectorized Antenna	995
3.	Auxiliary Equipment	841
4.	Installation and Testing	
	17 hours at $80 =	1,360
	Total	$6,196

WiFi Network Summary-Cedarburg-Grafton Area		
1.	Access Points	
	41 at $6,196 =	$254,036
2.	Gateway Stations	
	2 at $17,300 =	34,600
3.	Network Monitoring System	10,000
4.	Project Management and Engineering	55,000
	Total	$353,336

For rural wireless network, add:
Three sets of preamplifier, connectors and power injectors - $645

BACKHAUL WiMAX/WiFi NETWORK (802.11, 802.16) BASE STATION EQUIPMENT

Co-located Site		
1.	Site Preparation and Cleanup	$1,000
2.	Enclosures	200
3.	Utility Connection	2,000
4.	Power Conditioning and Backup	7,020
5.	21 dBi Antenna	150
6.	16 dBi Sectorized Antenna	1,404
7.	Transceiver Modules	
	WiFi (802.11) (2)	2,800
	WiMAX (802.16) (1)	3,000
8.	Installation and Testing	
	40 hours at $80=	3,200
9.	Miscellaneous	
	(Freight, cabling, and travel)	2,250
	Total	$23,024

New Site			
1.	Items 1-9 of co-located site above		$23,024
2.	Tower Erection		
	100 foot tower	$7,200	
	Foundation	4,100	
	Labor	2,200	
	Climb Shield	1,000	14,500
	Total		$37,524

Gateway Station		
1.	Site Preparation and Cleanup	$ 1,000
2.	Enclosures	10,850
3.	Utility Connection	2,000
4.	Power Conditioning and Backup	7,020
5.	31.2 dBi Antenna	3,874
6.	16 dBi Sectorized Antenna	1,404
7.	Transceiver Modules	
	WiFi (802.11) (2)	2,800
	WiMAX (802.16) (1)	3,000
8.	Internet Interconnection	
	MPLS Router	30,420
	Fiber Interconnect Equipment	20,000
9.	Installation and Testing	
	80 hours at $80=	6,400
10.	Miscellaneous	
	(Freight, cabling, and travel)	2,750
	Total	$91,518
	Additional if new tower is required	14,500
	Total if new tower is required	$106,018

Backhaul Network Cost Summary – Co-Location		
1.	Antenna Base Stations	
	47 at $23,024=	$1,082,128
2.	Gateway Stations	
	7 at $91,518=	640,626
3.	Project Management and Engineering	350,000
	Total	$2,072,754

Backhaul Network Cost Summary – New Tower Sites		
1.	Antenna Base Stations	
	47 at $37,524=	$1,763,628
2.	Gateway Stations	
	7 at $106,018=	742,126
3.	Project Management and Engineering	350,000
	Total	$2,855,754

Source: SEWRPC.

Table 19

OPERATING AND MAINTENANCE COST ESTIMATES FOR THE CEDARBURG-GRAFTON AREA WIRELESS NETWORK PLAN

ACCESS POINT COMMUNITY WIFI NETWORK

1. Electric Power 50 watts at $0.05/kwh	$ 1.80 per month
2. Maintenance and Network Management	25.00 per month
3. Pole Rental	10.00 per month
Total	$ 36.80 per month

BACKHAUL BASE STATION WIFI/WIMAX NETWORK – CO-LOCATION

1. Electric Power 200 watts at $0.05/kwh	$ 7.20 per month
2. Maintenance and Network Management	100.00 per month
3. Base Station Rental $4/foot/month 100 foot tower	400.00 per month
4. Internet Connection Costs (100 Mbps) 74 x 100 =	7,400.00 per month
Total	$ 7,907.20 per month

BACKHAUL BASE STATION WIFI/WIMAX NETWORK – NEW TOWERS

1. Electric Power 200 watts at $0.05/kwh	$ 7.20 per month
2. Maintenance and Network Management	100.00 per month
3. Land usage fee	1,060.00 per month
4. Transport Costs (100 Mbps) 74 x 100 =	$7,400.00 per month
Total	$8,507.20 per month

Note: The base station costs do not include any costs of land acquisition for site. Base station operators are often required to have liability insurance in the range of one million to three million dollars for each base station site, and may be required to post performance bonds for the potential removal of structures upon abandonment. The base station costs do not include these insurance or removal contingency costs.

Source: SEWRPC.

the Region as those areas that are shown on Map 32. As delineated on Map 32, the Cedarburg-Grafton area encompasses an area of 16.9 square miles, while the aggregate total area of all such urban service areas within the Region, encompasses an area of 975.4 square miles. Utilizing this multiplier, the total access infrastructure cost for urban community wireless areas within the Region approximates $20.3 million. Similarly, the attendant operating costs would total approximately $87,000 per month.

The infrastructure capital cost of the backhaul network for the Region, consisting of 47 base stations and seven gateway stations, as shown on Map 29, totals $2.1 million dollars, assuming the use of co-located sites. The operating cost of a backhaul station may be expected to range from $7,900 to $8,500 per month depending upon the type of installation, for a total operating cost of about $459,000 per month for all 47 base stations and seven gateway stations required.

The infrastructure capital cost for a rural community wireless plan are typified by such a plan for the Town of Wayne, Washington County. As shown on Map 33, four access points are required to serve the entire approximately 36 square mile area of the Town. The cost of the access infrastructure plan is estimated at about $82,000 for the four access points in the required network. Operating costs for each access point are estimated at about $37 per month, per station, or about $148 per month for all four access points. Applying a regional multiplier of 47.6[1] the total access infrastructure cost for rural community wireless areas within the Region approximates $3.9 million. Similarly, the attendant operating costs total about $7,000 per month. Since the access points would utilize the same backhaul station as would the urban community access station, no additional backhaul station capital or operating costs would be entailed.

Thus, the total capital cost of the community based wireless plan would approximate $26.3 million for the Region. The total operating cost would approximate $553,000 per month.

Regional Wireless Plan

A major shortcoming of the community-based wireless plan is its dependence upon community-by-community action for implementation. This may result in the creation of residual areas of the Region without broadband service. Since a major objective of the broadband regional wireless plan is universal service, an alternative regional

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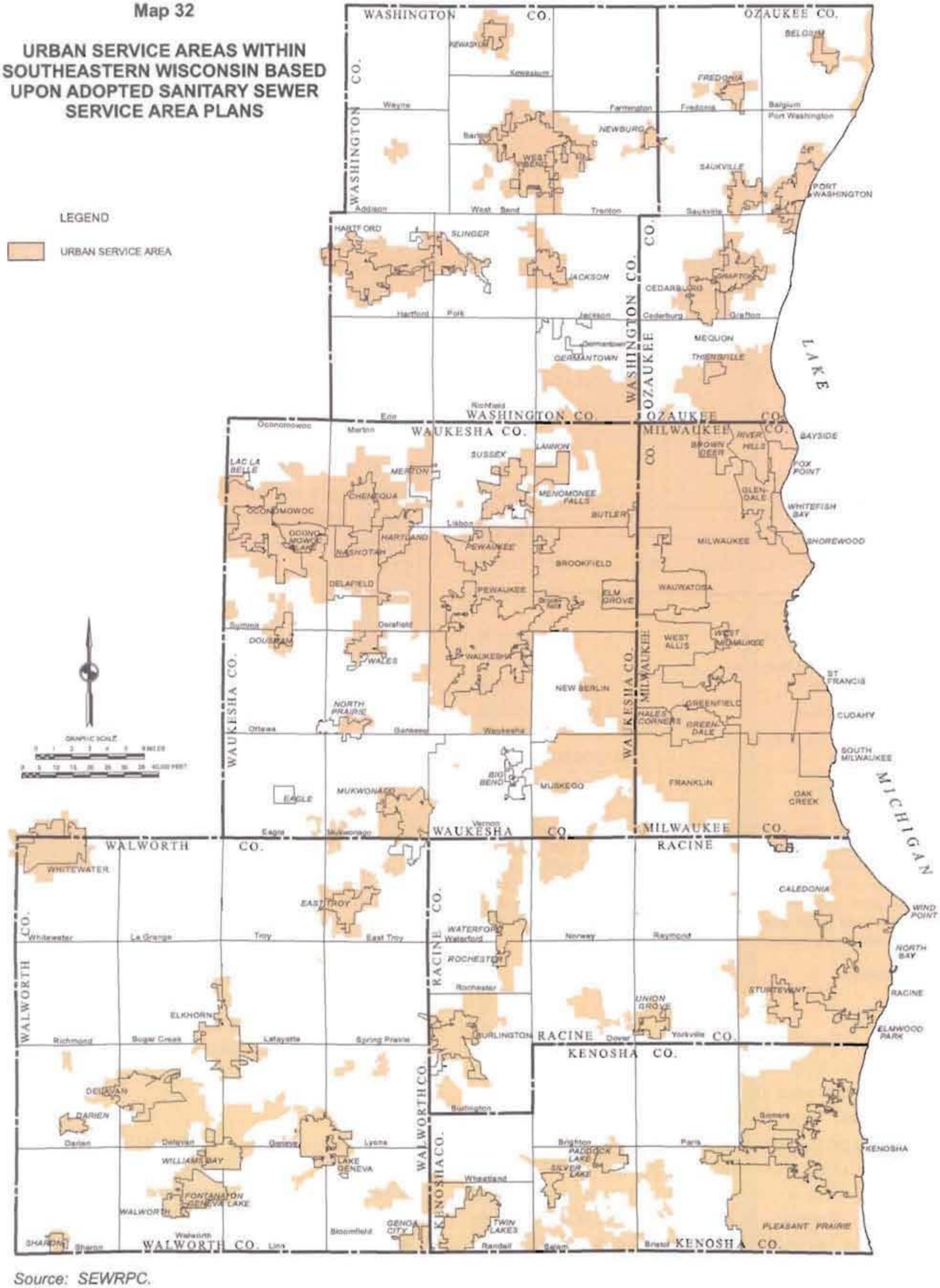
[1] *Derived by subtracting the aggregate total regional urban service area of 975.4 square miles from the total area of the Region of 2,689.8 square miles and dividing the remainder by 36 square miles.*

Map 32

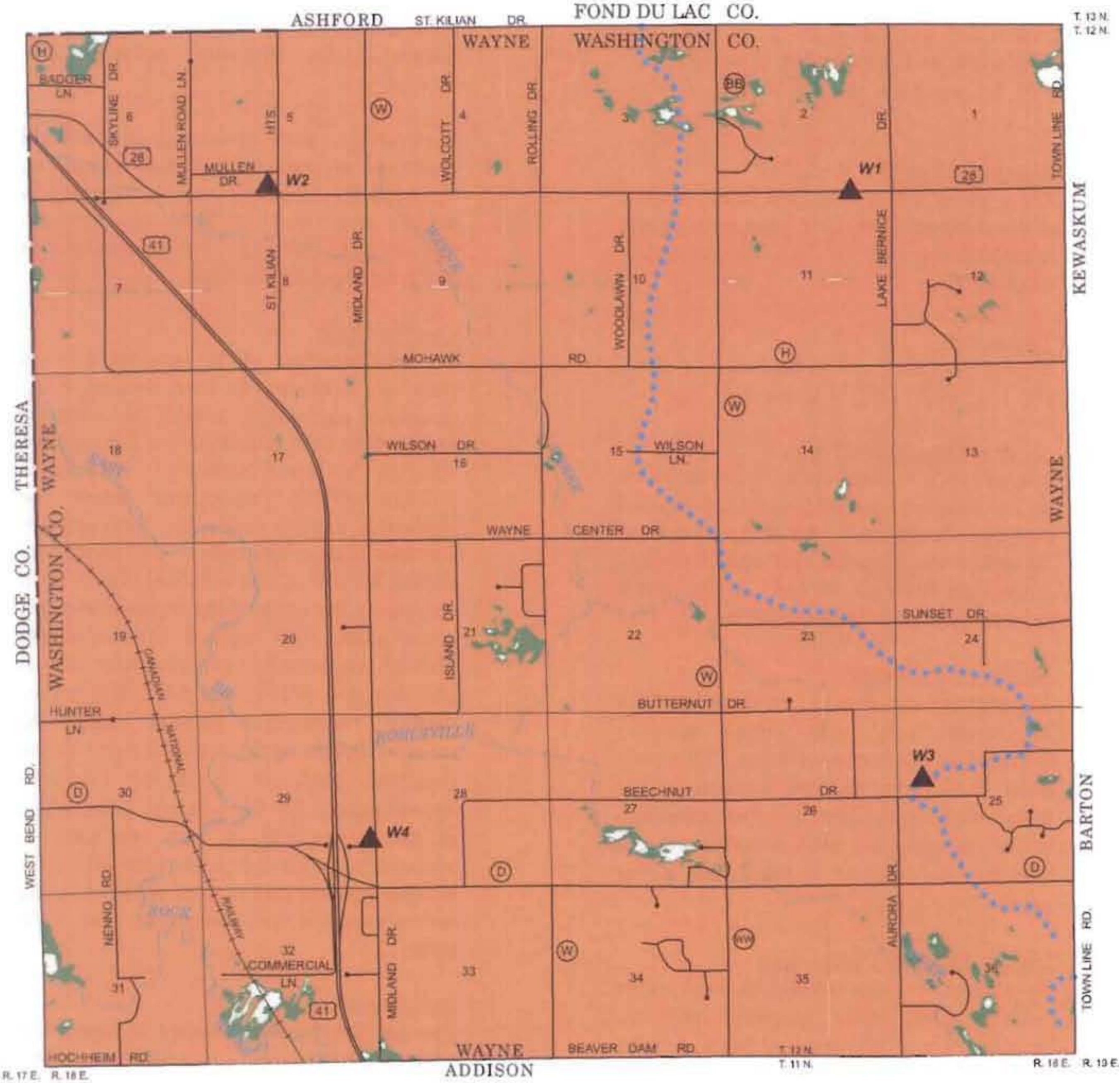
URBAN SERVICE AREAS WITHIN SOUTHEASTERN WISCONSIN BASED UPON ADOPTED SANITARY SEWER SERVICE AREA PLANS



Source: SEWRPC.

Map 33

POTENTIAL LOCATIONS OF WiFi ACCESS POINTS AND ATTENDANT PERFORMANCE OF ACCESS NETWORK FOR FIXED USERS IN THE TOWN OF WAYNE: ACCESS POINT TO REMOTE



LEGEND

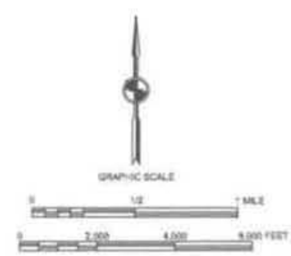
▲ ACCESS POINT LOCATIONS

W3 IDENTIFICATION NUMBER

RECEIVED POWER AT REMOTE: GREATER THAN -113.0 dBmW, THROUGHPUT: 24 Mpbs TO 54 Mbps

RECEIVED POWER AT REMOTE: -121.0 TO -113.0 dBmW, THROUGHPUT 6 TO 24 Mbps

AREA NOT WITHIN ACCEPTABLE COVERAGE



Source: SEWRPC.

wireless plan was developed. This broadband WiFiA-based system is designed to serve fixed and nomadic users in all geographic areas of the Region from the inner city of Milwaukee to the most rural areas of Walworth and Washington Counties. This plan would be specified to offer the following features:

1. Frequency Band
   The regional wireless system would operate in the unlicensed 5.8 GHz band separate and noninterfering with the 2.4 GHz community wireless band.

2. Technology
   System operation would be based on IEEE 802.11a WiFiA OFDM technology.

3. Antenna Base Stations Sites
   The network infrastructure would be based on 141 existing antenna tower sites installed on a co-location basis. An antenna height of 30 meters was assumed although that height could vary from site to site. A four sector antenna configuration is employed.

4. Antenna Site Density
   The antenna site density, as shown in Map 34, would vary with higher densities provided in urban service areas. This variation is required, in part, because of the higher building "clutter" in urban areas, and in part to serve the heavier traffic volume that may be expected in areas with higher population density.

5. Internet Gateway Connections
   Because of the expected high network traffic volume, fiber optic gateway interconnections would be made at each antenna base station site. Such interconnection implies fiber optic cable availability at each site. Since these co-location sites already serve other cellular/PCS wireless networks, there is a high likelihood that fiber optic accessibility is already present at each site.

6. Repeater Sites for Nomadic Users
   Enhanced service for nomadic users would be provided under this plan with repeater sites located at 6 meter—lamp pole—heights in areas requiring such service. With 141 base station sites each having four 90 degree sectors, there are 564 possible sector sites for repeater stations. Many of these sectors may be expected to be in areas unsuitable for extensive nomadic user service.

   Furthermore, with advancing antenna and electronic technology in laptop computers, the need for repeaters may be expected to decline over time as fixed and nomadic transceivers become more similar in performance characteristics.

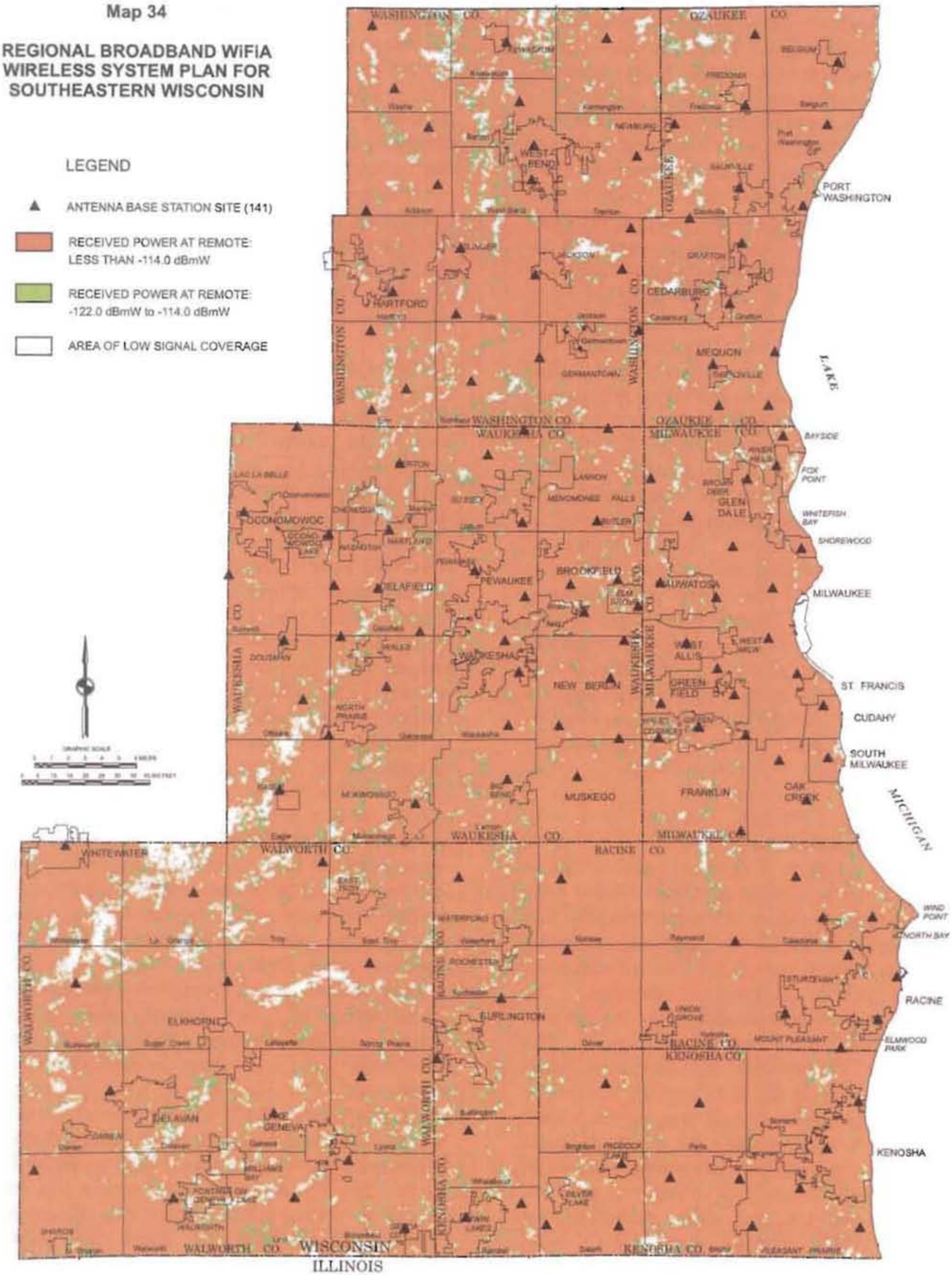
7. Cost Structure
   The cost structure of the regional wireless plan as it relates to base station infrastructure equipment would be virtually identical to that estimated for the regional wireless backhaul network. The same 802.11a WiFiA equipment would be applicable to both networks. Both provide for four sector operation. This similarity allows for use of the backhaul cost data in estimating the costs of the regional wireless access plan. The regional wireless access plan of necessity has a higher base station site density—141 versus 54. The higher density requirement results from the assumed height of the serviced user. In the backhaul plan, it is a six meter—approximately 20 feet—access point while in the access plan, it is a two meter—approximately six feet—user site. While the number of base station sites is larger in the access plan, the unit base station cost is the same.

8. Performance
   The network layout as shown in Map 29 is designed to provide 24 megabits per second throughput performance to fixed users for the entire Region. The few sub-performance areas noted on the map may also be upgraded using the same repeaters employed to enhance the service to the nomadic users.

9. County Representation
   The 141 antenna base sites are represented in each of the seven counties as follows: Kenosha 15, Milwaukee 24, Ozaukee 14, Racine 15, Walworth 14, Washington 23, and Waukesha 36.

Map 34

REGIONAL BROADBAND WiFiA WIRELESS SYSTEM PLAN FOR SOUTHEASTERN WISCONSIN



Source: SEWRPC.

Costs
The antenna base station equipment costs are detailed in Table 18. Separate cost summaries are provided for both co-location and new sites. Since the plan herein presented is based upon co-located sites, only co-located site cost data were used in the cost estimate. Some of the selected co-location sites may encounter difficulties in arranging with site owners for co-location. There are, however, 1,010 cellular/PCS antenna base station sites in the Region. With this large number of sites, substitute sites should be available in almost all areas so as not to significantly affect the cost of this plan estimate.

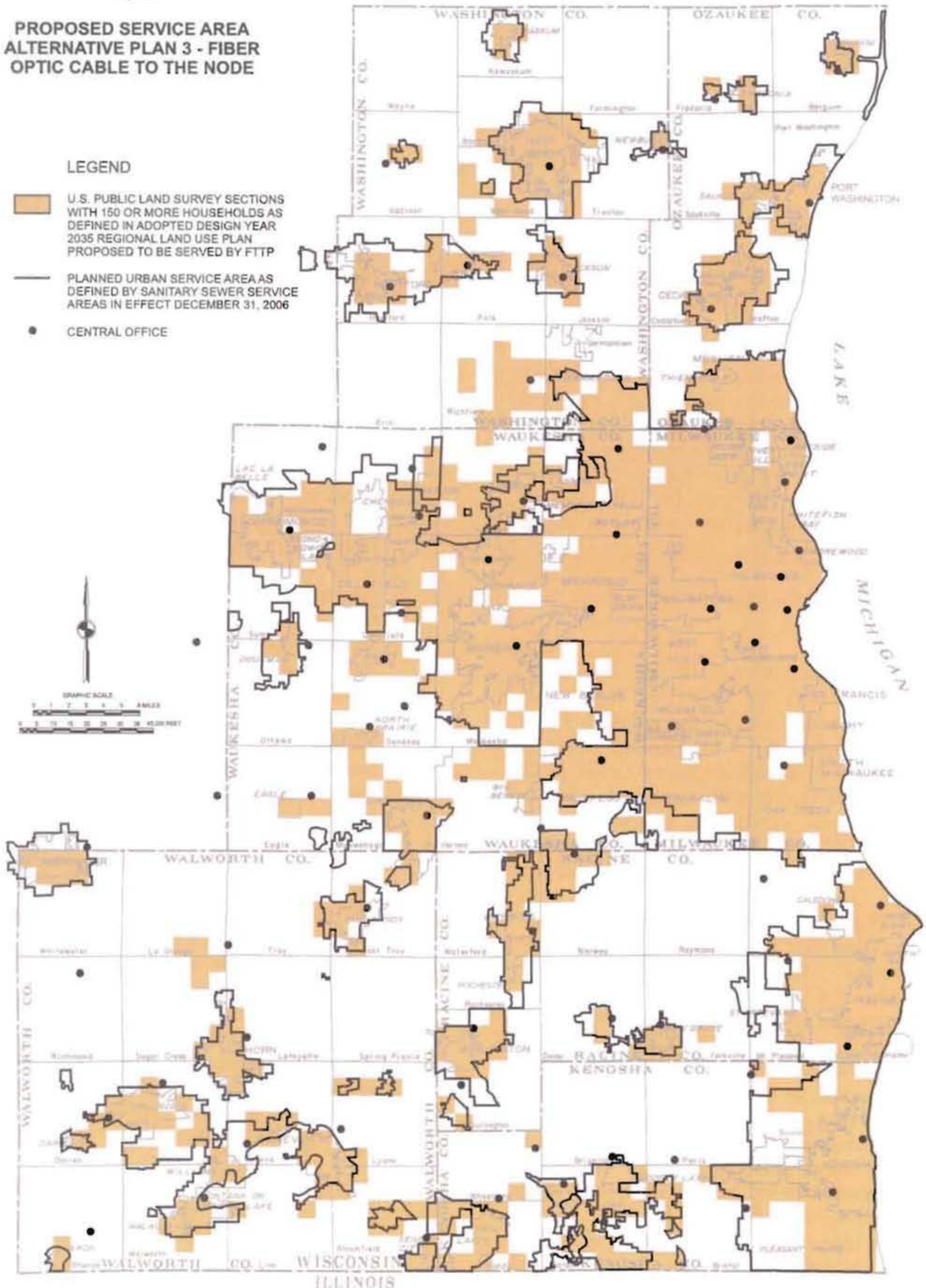
The only addition to the Table 18 site cost summary is a $2,500 fiber optic interconnection which was adjudged as the typical connection charge if fiber optic cable is available at the site. With 141 planned sites in the regional wireless plan and with an estimated site cost of approximately $25,500, the total estimated capital cost for the required wireless communications infrastructure equipment is approximately $3.6 million including the cost of fiber optic interconnections. Additional systems infra-structure costs relate to the cost of bringing fiber to each of the 141 sites. These costs, estimated in cooperation with Time Warner Telecom and Charter Communications, approximate $2.8 million. Thus, the total capital cost of this alternative plan is estimated to be $6.4 million. Operating costs are estimated at $987,000 per month based on a rate of $7,000 per month for a capacity of 100 megabits per second at each site.

Fiber-to-the-Node (FTTN) Alternative Wireline Plan
The Fiber-to-the-Node (FTTN) Alternative Plan is based upon the previously described Alcatel 7330 Intelligent Services Access Manager (ISAM). The early stages of this planned network are being deployed by AT&T in its ILEC territory within the Region as part of its Project Lightspeed. The alternative plan covered would extend the network into other ILEC areas within the Region. The envisioned FTTN network deployment is based upon the location of the ILEC central offices, as documented in Chapter V of this report. Each central office would support a set of remote nodes that in turn would service users within a radius of about 3,000 feet – comprising an approximately one square mile service area. The extent of the envisioned FTTN network deployment would depend upon the household density pattern within the Region. A threshold household density of 150 households per square mile was selected as the minimum density for service under the FTTN alternative plan since this standard results in an average density in the service area of about 1,343 households per square mile. Such an average household density coupled with a 20 percent "take-rate" assumption would provide for about 200 users per square mile which is the capacity of the smallest ISAM equipment unit. Larger take-rates could be supported by the installation of 400 or 800 line ISAM units, but the plan would provide for efficient utilization of even the smallest 200 nodal infrastructure.

The areas of the Region which may be expected to have a household density of 150 households per square miles or more in the year 2035, the design year of the adopted regional land use plan, are shown on Map 35. These areas, in aggregate, encompass a total of 953 square miles, or about 35 percent, of the total area of the seven-county Region. The areas meeting or exceeding the minimum household density standard as shown on Map 35 include areas of such density existing in the inventory base year 2000, as well as such areas expected to exist in the plan design year 2035. The mapped areas therefore include a number of small scattered and discontinuous areas meeting the minimum density standard. Such small, scattered, and discontinuous areas may be expected to be located beyond the reasonable service area of a FTTN wireline telecommunication system. Map 35 also includes a delineation of the planned urban service areas within the Region, the same areas as those shown on Map 32 of this report. These areas may be expected to accommodate anticipated urban development within the Region to the adopted regional land use plan design year 2035; and represent those areas of the Region which the adopted land use plan envisions being provided with a full range of urban facilities and services, including sanitary sewerage, public water supply, mass transit, and high speed broadband telecommunications. The urban service areas in aggregate encompass a total of 975 square miles or about 36 percent of the total area of the seven-county Region. In the base year of the plan – 2000 – about 477 square miles of this planned urban service area were actually devoted to urban development. This area is expected to increase to about 639 square

Map 35

PROPOSED SERVICE AREA ALTERNATIVE PLAN 3 - FIBER OPTIC CABLE TO THE NODE



miles by the year 2035. The latter area, however, may be expected to contain about 92 percent of the anticipated year 2035 resident population of the Region of 2.8 million persons; about 93 percent of the 27,600 acres of land anticipated to be devoted to commercial use; and about 90 percent of the land anticipated to be devoted to industrial use in that year.

The FTTN Alternative Plan is central office oriented, so that the deployment must consider proximity to central office locations as well as housing density. These central offices, previously displayed in Map 32 of the report, are also shown on Map 35 in conjunction with the envisioned service area of the FTTN Alternative Plan. Although AT&T is the only regional wireline carrier that is known to be committed to the deployment of an FTTN network within the Region, the envisioned service area of the FTTN Alternative Plan includes other areas of the Region serviced by ILEC carriers located within the delineated service area of the plan.

The FTTN plan has the following features:

1. Technology
An advanced version of DSL technology known as VDSL—for very high speed DSL—is the basis of the proposed FTTN Alternative Plan. Also known as International Telecommunications Union (ITU) Standard G.993, VDSL currently exists in two forms: VDSL—ITU Standard G.993.1, and VDSL2 ITU Standard G.993.2. VDSL has a maximum downlink transmission rate of 13 to 55 megabits per second, while VDSL2 has a maximum downlink transmission rate of 10 to 100 megabits per second. This asymmetrical nature of all forms of DSL constitutes an important limitation of the technology. Currently, the uplink transmission rates are limited to one megabit per second. Such a bandwidth allocation, while unimportant to many users, does limit certain applications such as video-conferencing, or the need to transmit large data files, where symmetrical data transmission rates are essential to quality video communications. Most of ILEC service providers offer a range of other high speed data equipment and services for symmetrical communications such as OC-1 (also called T3 or DS-3) lines, but these services are typically offered at much higher cost rates than the contemplated FTTN network services.

The FTTN networks currently being deployed by ILEC service providers are primarily aimed at the residential entertainment (television) market. Bandwidth allocation heavily favors downstream broadcasting and website downloading. Such networks are not particularly supportive of industrial and commercial communication which require more balanced symmetric communications channels.

It is of interest to note that DSL in all of its forms transmits data using discrete multitone (DMT), a wired version of orthogonal frequency division multiplexing (OFDM), that is widely used in wireless standards such as WiFi and WiMAX. The data signal to be transmitted is divided into multiple low speed data paths. These paths are modulated on hundreds or thousands of adjacent carriers over a broad spectrum. The medium from the central office to the node is fiber optic cable. The medium from the node to the user is the twisted wire pair telephone cable made with Number 24 or 26 gauge copper long used for voice telecommunications systems.

2. Range
Although a radius of 3,000 feet is the most frequently quoted range of VDSL, network performance varies with the distance from the local node. Maximum data transmission rates depend upon the signal-to-noise ratio (SNR) which declines with distance from the node. Users located closer to the node with a higher SNR will experience higher transmission rates. The range of VDSL can extend as far as approximately 4,500 feet from the node, and VDSL2 as far as approximately 5,000 feet.

3. Cost Structure
The deployment costs of the FTTN Alternative Plan include the central office, node, fiber optic cable link and user premise